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(54) Title: **BIOABSORBABLE, BIOBENEFICIAL POLYESTER POLYMERS FOR USE IN DRUG ELUTING STENT COATINGS**

(57) Abstract: This disclosure covers polymers, some of which are useful in medical device applications. Some of these medical devices are implantable within a mammalian body, such as in a body lumen. The copolymers comprise at least one alcoholic moiety derived from a diol, triol, or polyol. Additionally, the copolymers comprise an acidic moiety, derived from a polycarboxylic acid, and a biobeneficial moiety. Some of these copolymers are biodegradable or bioerodable. Medical devices comprising these polymers and methods of making these polymers are within the scope of this disclosure.

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**Bioabsorbable, Biobeneficial Polyester Polymers for Use In Drug
Eluting Stent Coatings**

BACKGROUND

A current paradigm in biomaterials research is the control of protein adsorption on the surface of implantable medical devices. Uncontrolled protein adsorption, leading to a mixed layer of partially denatured proteins, is a hallmark of current biomaterials when implanted. Current surfaces present different cell binding sites from adsorbed plasma proteins such as fibrinogen and immunoglobulin G. Platelets and inflammatory cells such as monocyte/macrophages and neutrophils adhere to these surfaces. When so activated, they secrete a wide variety of pro-inflammatory and proliferative factors. These unfavorable events can be controlled by the use of non-fouling surfaces. Non-fouling surfaces are surfaces that absorb little or no protein, primarily due to their hydrophilic surface properties. One prior art approach is to use hyaluronic acid and polyethylene glycol to provide this non-fouling surface characteristic. Biobeneficial coatings are surface coatings that are intended to provide a biological benefit without releasing pharmaceutically active agents. Another type of biobeneficial coating contains free radical scavengers to preserve nitric oxide and prevent oxidative damage.

Langer et al. have published a type of bioabsorbable, polyester polymer that they have dubbed "Biorubber". (Nature Biotechnology, vol. 20, p. 602, June 2002) This polymer is a polyester copolymer composed of sebacic acid and glycerol. It is a crosslinked elastomer, but possesses no biobeneficial or bioactive moieties. Improved polymers with non-fouling surfaces or with biobeneficial surfaces remain a goal in this art.

SUMMARY

This invention relates to copolymers, some of which are useful in medical device applications. Some of these medical devices are implantable within a mammalian body, such as in a body lumen. The copolymers comprise at least one alcoholic moiety derived from a diol, triol, or polyol. Additionally, the copolymers comprise an acidic moiety, derived from a polycarboxylic acid, and a biobeneficial moiety. Some of these copolymers are biodegradable or bioerodable. Medical devices comprising these polymers and methods of making other polymers are within the scope of this invention.

DETAILED DESCRIPTION

A family of bioabsorbable, non-fouling (biobeneficial) polyester polymers is disclosed. In some embodiments, these polymers compose the base material for implantable medical devices. In some embodiments, implantable medical devices comprise these polymers. And in some
5 embodiments, these polymers compose implantable medical device coatings. This family of polymers comprises the following basic components:

- (1) moieties derived from aliphatic diols, triols, or polyols;
- (2) moieties derived from polycarboxylic acids (carboxylic acids containing more than one acid functionality); and
- 10 (3) biobeneficial, non-fouling, or bioactive moieties.

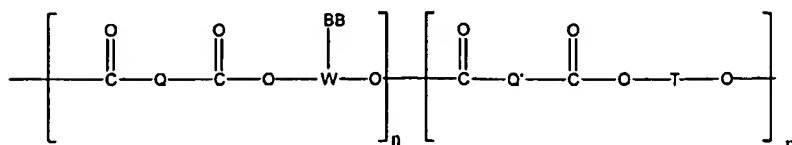
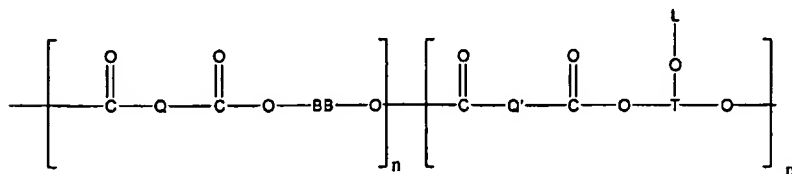
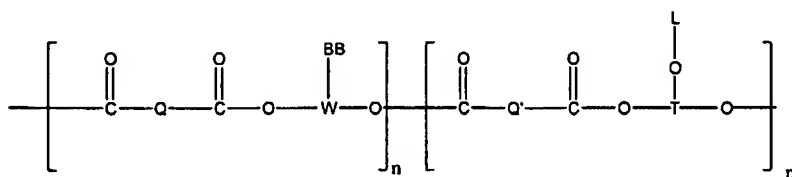
Some invention embodiments are block copolymers of one or more diols, triols, or polyols with a toxicologically acceptable acid monomer (polycarboxylic acid) such as the following: C₂ to C₁₂ straight chain, aliphatic diacids, specifically oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azaleic acid, and sebacic acid. Longer chain lengths,
15 such as found in dodecandioic acid, tetradecandioic acid, and hexadecandioic acid, are also possible. Polycarboxylic acids include citric acid and tartaric acid. Unsaturated polycarboxylic acids include fumaric acid and muconic acid. Lastly, useful aromatic polycarboxylic acids include terephthalic acid, isophthalic acid, phthalic acid, 1,6-bis(p-carboxy phenoxy)hexane, 1,3-bis(p-phenoxy carboxy)propane, and 1,4-bis(p-phenoxy carboxy)butane. In some invention
20 embodiments, the toxicologically acceptable polycarboxylic acid monomer specifically excludes sebacic acid.

Some invention block copolymers can be represented by the following formula:
[AB]_n[A'B']_m. In this formula A represents a moiety derived from an aliphatic diol, triol, or polyol. B represents a moiety derived from a polycarboxylic acid. In some embodiments these
25 are limited to a toxicologically acceptable polycarboxylic acid monomer; in these or other embodiments, polycarboxylic acid monomers are selected from those specifically disclosed above. A' represents a moiety derived from an aliphatic diol, triol, or polyol that is the same as or different from A. And B' represents a moiety derived from a polycarboxylic acid that is the same as or different from B. n and m represent the relative length of each block in this block
30 copolymer.

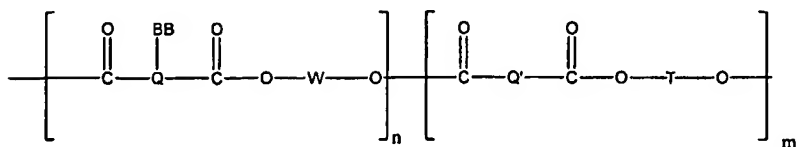
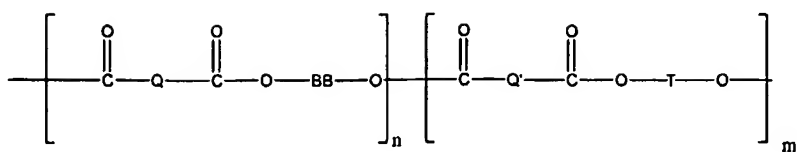
For purposes of this disclosure we define the soft block as having lower T_g or being highly water swellable. In some embodiments, the block labeled "n" contains the BB moiety and is, therefore the soft segment or soft block because most biobeneficial moieties are hydrophilic and absorb water. The other block, labeled by "m", is referred to as the hard segment. For purposes
 5 of this disclosure, we define the hard blocks as the blocks with a lower water absorption or a higher T_g .

Invention copolymers can be linear or branched and can be cross-linked when desired. In some instances, cross-linking, occurs through functional groups pendant from the polymer backbone. For instance, in some embodiments the functional groups from acids in the backbone
 10 can serve as the cross-linking site. In other embodiments, the unsaturation in an unsaturated diacid serves as the cross-linking site. In yet other embodiments, hydroxyl groups are pendant from the polymer backbone and serve as the cross-linking site. Those of ordinary skill in the art will recognize that other ways of achieving cross-links between polymer chains can be applied to invention copolymers. For example, to UV crosslink the polymers some embodiments have UV
 15 polymerizable groups in the monomers. Such groups are typically acrylates or methacrylates. The general scheme would include replacing the hydroxyl and carboxylic acid groups with acrylate or methacrylate. This gives rise to another class of polymers.

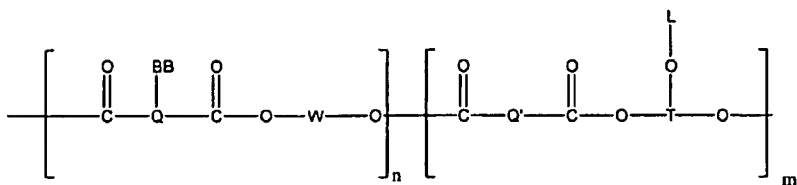
Some invention block copolymers can be represented by the following formulas:



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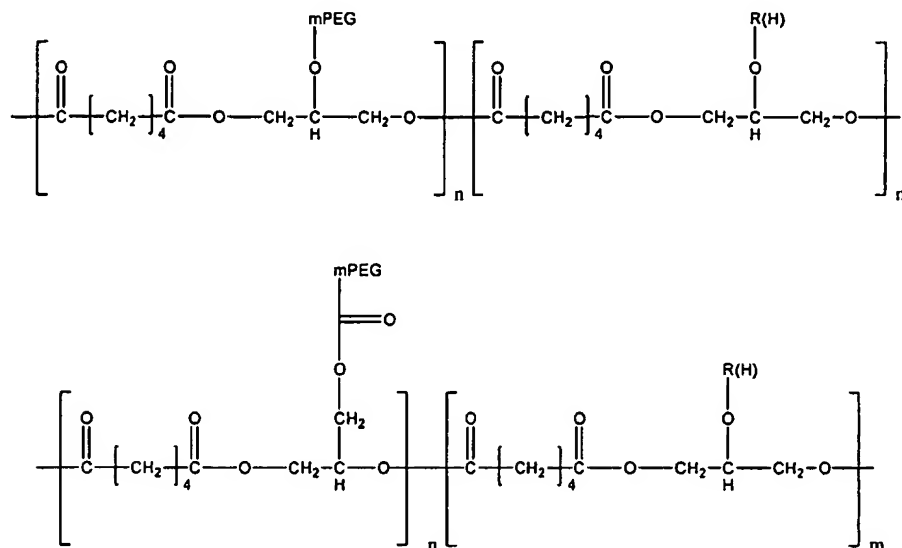
or



- 5 In these formulas, Q represents a 1-18 carbon-atom hydrocarbon chain; W represents a 1-8 carbon-atom hydrocarbon chain; T represents a 1-16 carbon-atom hydrocarbon chain; and BB represents a biobeneficial moiety. For purposes of this disclosure, hydrocarbon chains are defined as chains containing 1-50 carbon atoms and include straight and branched alkyl chains, chains containing pendant or in-chain rings, chains containing pendant or in-chain rings and alkyl
- 10 substitutions, and chains containing aromatic groups and alkyl substitutions. Suitable substituted hydrocarbyl chains are hydrocarbyl chains as defined above that are independently substituted with one or more halogen, amido, phosphido, alkoxy, ether, sulfide, phosphate ester, or other Lewis acidic or basic functionality. n and m represent the length of the blocks. In some
- 15 embodiments, n takes any value from 2 to 1250. In some embodiments, m takes any value from 10 to 4500. n:m is usually within 1:2250 to 125:1. This means that in some embodiments the m-block is 2250 repeat units long while the n-block is 1 repeat unit long. Finally, L represents a cross-linking group for those blocks containing a cross-link, and L represents hydrogen for those blocks not containing a cross-link.

- 20 In the above formulas, a $-\text{CH}_2-$ group can be substituted with a $-\text{Si}(\text{OR})_2-$ group in which R is an alkyl, phenyl, or halogenated alkyl containing 1-6 carbon atoms. A $-\text{CH}_2-$ group can be substituted with a keto group, $\text{C}=\text{O}$. And sulfur can be substituted for oxygen, thereby converting ether linkages into sulfide linkages.

In some embodiments, the block copolymer may comprise non-fouling or biobeneficial moieties. The formulas shown below represent two specific classes of invention polymers.



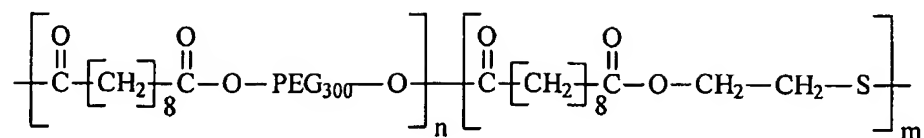
- 5 This polymer is comprised of moieties derived from glycerol, adipic acid, and mPEG. The diblock structure indicates that not all of the glycerol is derivatized with mPEG. A portion of the glycerol-derived moiety is involved in an ester crosslink as indicated by (R) or has a free hydroxyl as indicated by (H). In this structure, the PEG is pendant, but it can also be in the polymer backbone.

10 Diol, Triol, or Polyol

The diol, triol, or polyol component is a chain with one or more alcohol functionalities. In some embodiments this component is a mixture of di- or multi-alcoholic molecules such as mixtures with PEG diols, glycerol, other triols, etc. In some embodiments, this component is a mixture comprising PEG diols, PLURONIC (TM) diols, or glycerol or other triols.

- 15 In the diol, triol, or polyol at least one hydroxy group should be present in order to form the hydrolysable ester linkage. The hydrocarbyl groups T and W may have unsaturation. In polymer precursors containing groups T and W, sulfhydryl and amino groups can substitute for hydroxyl groups as long as at least one hydroxyl group remains to form an ester bond.

Here is a polymer with a sulfhydryl group substitution: one using mercaptoethanol,
20 sebacic acid, and PEG300.



Criteria for choosing the polyol component depends on whether the component is for hydrocarbyl group T or group W. In addition to two hydroxyl groups, in order to be a part of the polymer backbone, group W requires a third, pendant functionality to attach to the biobeneficial moiety. If group T is to have a pendant hydroxyl or alkoxy group, it must also have this third functionality. However, when group T does not have or is not desired to have any pendant functional groups, it can be difunctional. In some embodiments having excellent biocompatibility, the polyol or polyols are endogenous or have established biocompatibilities.

Suitable polyols are ethylene glycol, 1,2-propane diol, 1,3-propane diol, 1,4-butanediol, 1,5-butanediol, 1,6-hexanediol, 1,7-heptanediol, 1,8-octanediol, higher diols up to C₁₆, glycerol, trimethylol propane, pentaerythritol, cyclohexanedimethanol, serinol, diethanolamine, and saccharides such as erythrose, threose, ribose, arabinose, xylose, lyxose, dihydroxyacetone, erythulose, xylulose, aldoses, and ketoses. In some embodiments, polyols are 1,2-propanediol, 1,3-propanediol, 1,4-butanediol, 1,6-hexanediol, 1,10-decanediol, 1,12-dodecanediol, glycerol, serinol, diethanolamine, trimethylol propane, or pentaerythritol.

One embodiment uses phosphoryl choline-co-HEMA a biobeneficial, methacrylate copolymer. In this polymer, the phosphoryl choline group is attached to a methacrylate. These polymers are not usually hydroxy terminated, but certain living polymerization schemes will function with these hydroxy terminated polymer.

Tri- or multi-functional -OH can copolymerize in the backbone such that two of the hydroxyl groups act to incorporate the polyol chain into the polymer. This leaves one or more remaining hydroxyl groups to conjugate a bioactive moiety. Or, one or more of the remaining hydroxyl groups can serve as a cross-linking site.

Polycarboxylic Acid

The polycarboxylic acid is a compound with at least two carboxylic acid groups. For implant use, polycarboxylic acid used in this invention should be toxicologically acceptable. This means the toxicity it imparts to the polymer, and the toxicity of the monomer itself when released, should be low enough that the polymer can be used within a mammalian body. Specific examples of these include C₂ to C₁₂ straight chain aliphatic diacids, specifically oxalic acid, malonic acid,

succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azaleic acid, sebacic acid, and citramalic acid. Longer chain lengths, such as found in dodecanedioic acid, tetradecanedioic acid, and hexadecanedioic acid, are useful in the practice of this invention. Polycarboxylic acids include citric acid, tricarballic acid, and tartaric acid. Unsaturated polycarboxylic acids include fumaric acid and muconic acid. Lastly, useful aromatic polycarboxylic acids include terephthalic acid, isophthalic acid, phthalic acid, 1,6-bis(p-carboxy phenoxy)hexane, 1,3-bis(p-phenoxy carboxy)propane, and 1,4-bis(p-phenoxy carboxy)butane.

Specific examples of polycarboxylic acids include oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azaleic acid, sebacic acid, terephthalic acid, and citric acid. Particularly suitable examples include succinic acid, adipic acid, sebacic acid, tricarballic acid, citric acid, fumaric acid, terephthalic acid, and 1,3-bis(p-phenoxy carboxy)propane.

Biobeneficial Moiety

For purposes of this disclosure, the term “biobeneficial” is an umbrella description for any surface that provides biological benefit for an implantable medical device without the release of a pharmacologically active agent. Following this definition of “biobeneficial”, the term biobeneficial moiety is a moiety that imparts, either by itself or with another moiety, to a polymer or surface the characteristic of being “biobeneficial”. Within this umbrella definition, some surfaces may be regarded as non-fouling and some as bioactive, whereas others may be regarded as hemocompatible or non-thrombogenic. Also, biobeneficial moieties include moieties that have any combination of bioactive, non-fouling, or hemocompatible characteristics.

Biobeneficial moieties that are primarily non-fouling are poly(ethylene glycol), polypropylene glycol, PLURONIC (TM) surfactants — block copolymers of polyethylene glycol and polypropylene glycol, hydroxy functional poly(vinyl pyrrolidone) dextran, dextrin, sodium hyaluronate, hyaluronic acid, elastin, chitosan, water-soluble chitosan, water-soluble heparin, water-soluble elastin, tropoelastin, Albumin, and poly(2-hydroxyethyl methacrylate). Biobeneficial moieties that are primarily hemocompatible are heparin, hirudin, and sulfonated polystyrene. Particular bioactive agents would include superoxide dismutase mimetics, anti-oxidants, and free radical scavengers. Biobeneficial moieties can possess a combination of these or other properties.

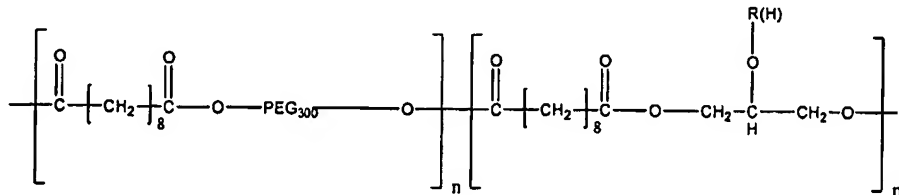
A caveat is that the maximum molecular weight of this component should be low enough so that the released molecule can pass through the kidneys, e.g., in some embodiments the maximum molecular weight of this component is less than or equal to 40,000 Daltons, if the polymer is not absorbable by hydrolysis or enzymolysis. In this respect, a maximum molecular weight of 20,000 Daltons is more preferred. If the biobeneficial moiety itself is hydrolyzed or metabolized by the body, as would be the case with heparin, then the maximum molecular weight could be larger than the renal passage cutoff of approximately 40,000 Daltons.

Invention polymers can be linear or crosslinked. The biobeneficial components can be pendant or in the polymer backbone. A polymer of this invention can contain more than one type of biobeneficial moiety. For example, a non-fouling moiety can be pendant on select repeat units designated by "n" while a bioactive moiety could be present on other repeat units designated by "m". Bioactive moieties can be selected from PEG diols with molecular weights from 300-30,000.

The choice of values for "n" and "m" determines the total weight fraction of each block in the final polymer. For linear polymers there are limits to the amount of biobeneficial moiety that can be incorporated while retaining acceptable mechanical properties. For example, the non-fouling biobeneficial moieties are largely very hydrophilic and many are water-soluble. If the weight fraction of non-fouling component moieties becomes greater than approximately 80% by weight, then the linear polymer can swell excessively, or even dissolve, in water. Therefore, the weight fraction of non-fouling component moieties is chosen to be less than approximately 80 percent by weight in some embodiments. But if the weight fraction of the non-fouling moiety is too low, not enough will be present to modify the surface properties of the polymer. This level depends of the particular polymer, but is in the range of 1-10 percent by weight, below which biobeneficial, non-fouling properties will be subtle. Therefore, the weight fraction of non-fouling component moieties is chosen to be greater than 1-10 percent by weight in some embodiments. In the case of crosslinked systems, the problems of polymer dissolution are eliminated. Excessive swelling can still occur, which can weaken the polymer coating in some embodiments. In the case of hemocompatible, biobeneficial moieties, similar concerns apply because larger amounts of these moieties give higher surface concentrations at the expense of mechanical properties due to excessive water swelling. Bioactive, biobeneficial moieties are not necessarily hydrophilic. In some embodiments, as much hemocompatible, biobeneficial moiety is incorporated into the polymer as can be incorporated into the polymer and still have the polymer retain acceptable mechanical properties for use in medical devices. For some embodiments, appropriate values of n

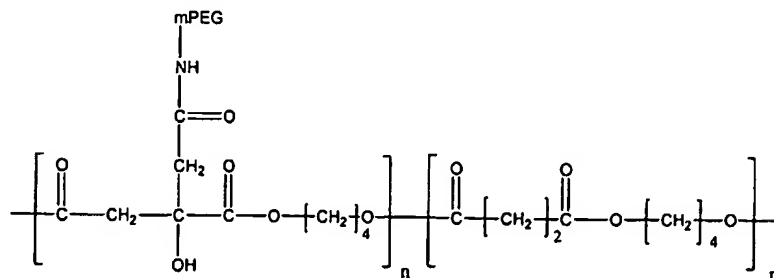
are between 2 and 1250. For some embodiments, appropriate values of m are between 10 and 4500.

One specific embodiment of invention copolymers is the crosslinked terpolymer of glycerol, sebacic acid, and polyethylene glycol (PEG300). This polymer has the structure shown
5 below.



The reactivities of PEG300 and glycerol are quite different, so it is advantageous to produce this polymer in a two-step process. Generally, one equivalent of PEG300 is combined with two equivalents of sebacic acid. This is heated under vacuum to produce a sebacic-acid-terminated PEG300. Useful reaction temperatures range from 80 to 140°C, under vacuum of 10
10 mtorr to 760 torr. Then, depending on the n:m target ratio and the final molecular weight desired in the copolymer, an additional amount of sebacic acid and glycerol, in a 1:1 mole ratio, is added, and the reaction is continued. Useful reaction parameters in this step include reaction temperatures of from 80 to 140°C, under pressures of 10 mtorr to 760 torr, for reaction times of
15 2 - 48 hours.

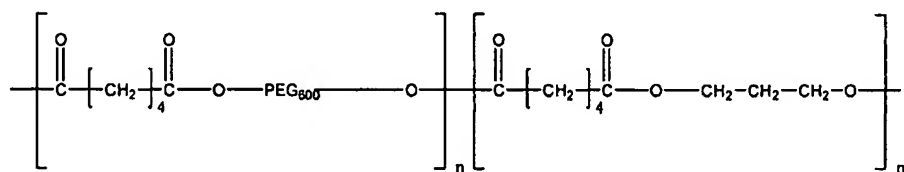
Another specific embodiment of invention copolymers is a grafted terpolymer of citric acid, succinic acid, butanediol, and mPEG. This polymer has the structure.



Another specific embodiment of the invention copolymers is a grafted terpolymer of
20 tricarballic acid, succinic acid, 1,4-butanediol and the monomethyl ether of polyethylene glycol MW=600 (mPEG600). Again, one method of making this polymer is a two-step process where

the mPEG is reacted first due to its lower reactivity. Generally, the mPEG is coupled to the tricarballic acid by coupling an amine-terminated mPEG (such as available from Nektar, formerly Shearwater Polymers) to tricarballic acid via carbodiimide chemistry. This mPEG-derivatized diacid is then combined with the desired amount of 1,4-butanediol and succinic acid in a 1:1 mole ratio. Instead of ester formation via dehydration using heat and vacuum, further addition of an appropriate carbodiimide, such as 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (EDC) or 1,3-dicyclohexylcarbodiimide (DCC), will couple the carboxylic acid and hydroxyl groups to form the polyester. In some embodiments, this yields a linear polymer that is solvent soluble and amenable to current stent coating processes.

Another specific embodiment of invention copolymers is a terpolymer of 1,3-propanediol, adipic acid, and PEG600. This polymer has the following structure.



Generally, this type of copolymer can also be synthesized in a two-step process. First, the total amount of adipoyl chloride is added to the reaction vessel under anhydrous conditions with an appropriate amount of pyridine to absorb the released HCl. The solvent is toluene. Next, dry PEG600 is added. After the PEG600 has reacted (which results in an adipoyl-chloride-terminated PEG600), 1,3-propanediol is added. 1,3-propanediol is a breakdown product of all biodegradable polymers containing the monomer trimethylene carbonate. 1,3-propanediol is biocompatible. In various embodiments, the molecular weight of the PEG can be varied, the diol can be varied, and the diacid can be varied. In some embodiments, the diacid is one or more of succinic, adipic, or sebacic acids. In some embodiments, this type of polymer is linear and solvent soluble. It is also possible to make copolymers with both pendant and in-chain biobeneficial moieties. This is particularly true in two-step reaction schemes where two different types of acid terminated, biobeneficial derivatized blocks can be synthesized separately, and then combined and further reacted with additional diacid and diol.

In various embodiments, the molecular weight of the PEG can be varied, the diol can be varied, and the diacid can be varied. In some embodiments, the diacid is one or more of adipic, succinic, and sebacic acid. In some embodiments this type of copolymer is linear and solvent soluble.

In some invention embodiments, the bioactive moiety is selected to have or to also have free-radical scavenging characteristics. Specific examples of useful bioactive moieties that have free-radical scavenging characteristics include superoxide dismutase or a nitric oxide donor.

5 In addition to being used as a non-fouling coating, invention copolymers may be coated onto a polymeric stent, a metal stent, or a bare metal stent, or they may be coated on top of a drug eluting coating already present on a stent. Alternatively, invention copolymers may be disposed between a stent and a drug-eluting coating. Also, invention copolymers can be used to construct polymer-based medical devices or can serve as the substrate from which medical devices (implantable or not) are constructed.

10 Invention copolymers can also be used as mixtures with other polymers. For example, invention polymers can be physically blended with PEG, POLYACTIVE (TM), or other biobeneficial polymers. These blends could be formulated to modulate biological outcome.

For purposes of this disclosure, "modulate biological outcome" means adjusting the polymer biobeneficial-component content in order to minimize fibrinogen absorption, platelet
15 binding, the number of adherent macrophages and inflammatory cells, and the degree to which inflammatory cells are activated.

These blends could also be formulated to modulate or tune the release rate of drugs from coatings, reservoirs, or particles composed of these blends and drugs or therapeutic agents. Blends with other polymers can be formulated to modulate the mechanical properties of invention
20 polymers. For instance, other polymers could be blended into invention polymers to modify mechanical properties or vice versa. Useful polymers for preparing such blends include polycaprolactone, poly(D,L-lactide), poly(L-lactide), poly(D,L-lactide-co-L-lactide), poly(glycolide), poly(D,L-lactide-co-glycolide), poly(dioxanone), poly(4-hydroxybutyrate), poly(3-hydroxybutyrate), poly(3-hydroxy valerate), poly(hydroxybutyrate-co-hydroxyvalerate),
25 poly(tyrosine derive carbonates), poly(tyrosine arylates), poly(imino carbonates), poly(trimethylene carbonate), poly(anhydrides), poly(orthoesters), and poly(ester amides).

In some embodiments coatings may be formed on medical devices using invention copolymers as the coating material base. In some embodiments this is accomplished by applying the copolymer of the drugs, polyol(s), and diacid(s) to the surface of the medical device before the
30 copolymer has been substantially cross-linked. Then the coating can be cross-linked slowly by heating the coating. Slow cross-linking is facilitated by the presence of the "third" hydroxyl

group, which is a secondary (or tertiary) hydroxyl. Alternatively, a cross-linking step can be carried out simultaneously during sterilization, such as heat or electron-beam sterilization.

Cross-linking (in bulk invention polymer or in coatings comprising invention polymer) can be carried out so that the cross-links form mainly between invention copolymer chains.

- 5 Alternatively, the cross-links can form between invention copolymer chains in blends, or between invention copolymers in one layer and the molecules or polymer chains in primer layers or in other polymer layers.

- Conventional therapeutic agents, such as small-hydrophobic drugs, may also be added to invention copolymers, making them bioabsorbable, drug-eluting systems. Conventional
10 therapeutic agents can be grafted on to the invention copolymers or can be mixed in the invention copolymers. Invention copolymers can be coated as blends with a variety of other biobeneficial polymers. Moreover, they can serve as base or topcoat layers for other biobeneficial polymer layers.

- The therapeutic agent can be for inhibiting the activity of vascular smooth muscle cells.
15 More specifically, the therapeutic agent can be aimed at inhibiting abnormal or inappropriate migration or proliferation of smooth muscle cells to prevent, inhibit, reduce, or treat restenosis. The therapeutic agent can also include active agent may be any substance capable of exerting a therapeutic or prophylactic effect in the practice of the present invention. Examples of such active agents include antiproliferative, antineoplastic, antiinflammatory, antiplatelet,
20 anticoagulant, antifibrin, antithrombin, antimitotic, antibiotic, and antioxidant substances as well as combinations thereof. An example of an antiproliferative substance is actinomycin D, or derivatives and analogs thereof (manufactured by Sigma-Aldrich 1001 West Saint Paul Avenue, Milwaukee, WI 53233; or COSMEGEN available from Merck). Synonyms of actinomycin D include dactinomycin, actinomycin IV, actinomycin I₁, actinomycin X₁, and actinomycin C₁.
25 Examples of antineoplastics include paclitaxel and docetaxel. Examples of antiplatelets, anticoagulants, antifibrins, and antithrombins include aspirin, sodium heparin, low molecular weight heparin, hirudin, argatroban, forskolin, vapiprost, prostacyclin and prostacyclin analogs, dextran, D-phe-pro-arg-chloromethylketone (synthetic antithrombin), dipyridamole, glycoprotein IIb/IIIa platelet membrane receptor antagonist, recombinant hirudin, thrombin inhibitor (available
30 from Biogen), and 7E-3B® (an antiplatelet drug from Centocor). Examples of antimitotic agents include methotrexate, azathioprine, vincristine, vinblastine, fluorouracil, adriamycin, and mutamycin. Examples of cytostatic or antiproliferative agents include angiopentin (a

somatostatin analog from Ibsen), angiotensin converting enzyme inhibitors such as CAPTOPRIL (available from Squibb), CILAZAPRIL (available from Hoffman-LaRoche), or LISINOPRIL (available from Merck & Co., Whitehouse Station, NJ), calcium channel blockers (such as Nifedipine), colchicine, fibroblast growth factor (FGF) antagonists, histamine antagonist, LOVASTATIN (an inhibitor of HMG-CoA reductase, a cholesterol lowering drug from Merck & Co.), monoclonal antibodies (such as PDGF receptors), nitroprusside, phosphodiesterase inhibitors, prostaglandin inhibitor (available from Glaxo), Seramin (a PDGF antagonist), serotonin blockers, thioprotease inhibitors, triazolopyrimidine (a PDGF antagonist), and nitric oxide. Other therapeutic substances or agents that may be appropriate include alpha-interferon, genetically engineered epithelial cells, dexamethasone, estradiol, clobetasol propionate, cisplatin, insulin sensitizers, receptor tyrosine kinase inhibitors and carboplatin. Exposure of the composition to the active agent should not adversely alter the active agent's composition or characteristic. Accordingly, the particular active agent is selected for compatibility with the blended composition. Rapamycin is a suitable active agent. Additionally, 40-O-(2-hydroxy)ethyl-rapamycin, or a functional analog or structural derivative thereof, is suitable, as well. Examples of analogs or derivatives of 40-O-(2-hydroxy)ethyl-rapamycin include but are not limited to 40-O-(3-hydroxy)propyl-rapamycin and 40-O-[2-(2-hydroxy)ethoxy]ethyl-rapamycin. The release rate active agents, such as 40-O-(2-hydroxy)ethyl-rapamycin, can be advantageously controlled by various methods and coatings as is known in the art.

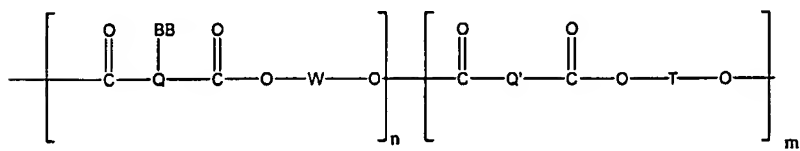
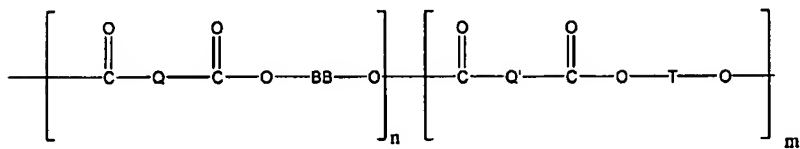
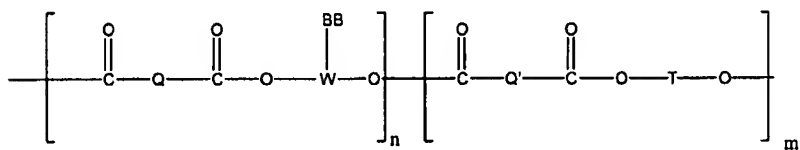
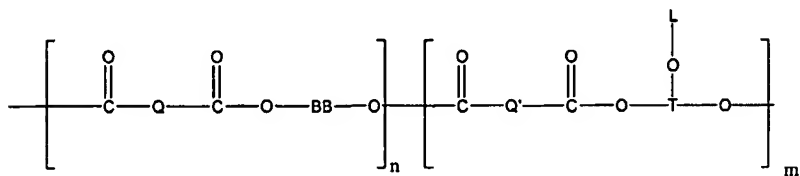
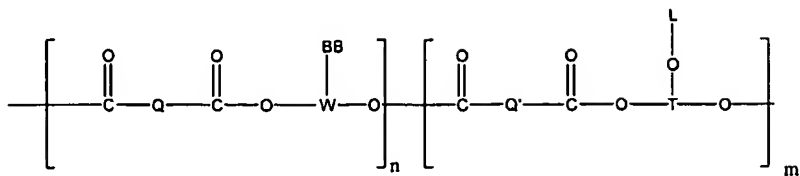
As stated above, invention block copolymers can be used with other polymers and biopolymers. Representative examples of polymers useful with invention block copolymers include ethylene vinyl alcohol copolymer, poly(hydroxyvalerate); poly(L-lactic acid); polycaprolactone; poly(lactide-co-glycolide); poly(hydroxybutyrate); poly(hydroxybutyrate-co-valerate); polydioxanone; polyorthoester; polyanhydride; poly(glycolic acid); poly(D,L-lactic acid); poly(glycolic acid-co-trimethylene carbonate); polyphosphoester; polyphosphoester urethane; poly(amino acids); cyanoacrylates; poly(trimethylene carbonate); poly(iminocarbonate); copoly(ether-esters) (e.g. PEO/PLA); polyalkylene oxalates; polyphosphazenes; biomolecules, such as fibrin, fibrinogen, cellulose, starch, collagen and hyaluronic acid; polyurethanes; silicones; polyesters; polyolefins; polyisobutylene and ethylene-alphaolefin copolymers; acrylic polymers and copolymers; vinyl halide polymers and copolymers, such as polyvinyl chloride; polyvinyl ethers, such as polyvinyl methyl ether; polyvinylidene halides, such as polyvinylidene fluoride and polyvinylidene chloride; polyacrylonitrile; polyvinyl ketones; polyvinyl aromatics, such as polystyrene; polyvinyl esters, such as polyvinyl acetate; copolymers of vinyl monomers

with each other and olefins, such as ethylene-methyl methacrylate copolymers, acrylonitrile-styrene copolymers, ABS resins, and ethylene-vinyl acetate copolymers; polyamides, such as Nylon 66 and polycaprolactam; alkyd resins; polycarbonates; polyoxymethylenes; polyimides; polyethers; epoxy resins; polyurethanes; rayon; rayon-triacetate; cellulose; cellulose acetate; 5 cellulose butyrate; cellulose acetate butyrate; cellophane; cellulose nitrate; cellulose propionate; cellulose ethers; and carboxymethyl cellulose.

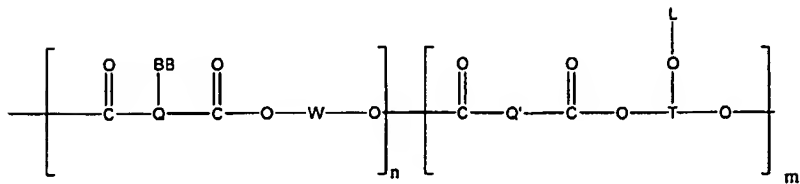
Examples of implantable devices for the present invention include self-expandable stents, balloon-expandable stents, stent-grafts, grafts (e.g., aortic grafts), vascular grafts, artificial heart valves, cerebrospinal fluid shunts, pacemaker electrodes, guidewires, ventricular assist devices, 10 artificial hearts, cardiopulmonary by-pass circuits, blood oxygenators, and endocardial leads (e.g., FINELINE and ENDOTAK, available from Guidant Corporation, Santa Clara, CA). The underlying structure of the device can be of virtually any design. The device can be made of a metallic material or an alloy such as, but not limited to, cobalt chromium alloy (ELGILOY), stainless steel (316L), high nitrogen stainless steel, e.g., BIODUR 108, cobalt chrome alloy L- 15 605, "MP35N," "MP20N," ELASTINITE (Nitinol), tantalum, nickel-titanium alloy, platinum-iridium alloy, gold, magnesium, or combinations thereof. "MP35N" and "MP20N" are trade names for alloys of cobalt, nickel, chromium, and molybdenum available from Standard Press Steel Co., Jenkintown, PA. "MP35N" consists of 35% cobalt, 35% nickel, 20% chromium, and 10% molybdenum. "MP20N" consists of 50% cobalt, 20% nickel, 20% chromium, and 10% 20 molybdenum. Devices made from bioabsorbable or biostable polymers could also be used with the embodiments of the present invention.

What is claimed is:

1. A polymer with the following formula:



or



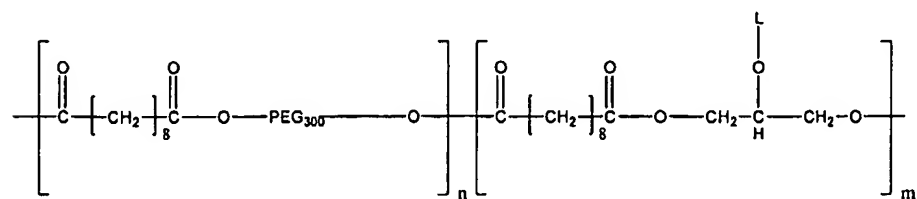
wherein

- a) n is 2 to 250;
- b) m is 10 to 4500;
- c) L represents a cross-linking group or hydrogen;
- d) Q and Q' represent the same or different, 1-18 carbon atom hydrocarbon chains;
- e) W represents a 1-8 carbon atom hydrocarbon chain;
- f) T represents a 1-16 carbon atom hydrocarbon chain; and
- g) BB represents a biobeneficial moiety.

- 2. A polymer comprising:
 - a) an alcoholic moiety derived from an aliphatic diol, triol, or polyol;
 - b) an acidic moiety derived from a polycarboxylic acid; and
 - c) a biobeneficial moiety having biobeneficial characteristics, a non-fouling moiety having non-fouling characteristics, a bioactive moiety having bioactive characteristics, or a moiety that has any combination of biobeneficial, non-fouling, or bioactive characteristics.
- 3. The polymer of claim 2 wherein the alcoholic moiety is derived from a diol or a saccharide having from 1 to 25 carbon atoms
- 4. The polymer of claim 3 wherein the alcoholic moiety is derived from a diol having 1 to 16 carbon atoms
- 5. The polymer of claim 2 wherein the alcoholic moiety is derived from at least one of ethylene glycol, 1,2-propane diol, 1,3-propane diol, 1,4-butanediol, 1,5-butanediol, 1,6-hexanediol, 1,7-heptanediol, 1,8-octanediol, higher diols up to C16, glycerol, trimethylol propane, pentaerythritol, cyclohexanedimethanol, serinol, diethanolamine, or saccharides.

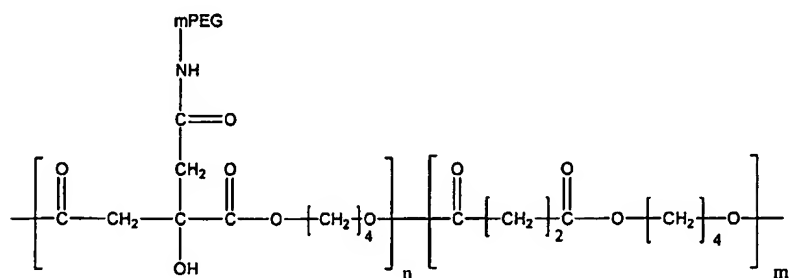
6. The polymer of claim 5 wherein saccharides are selected from erythrose, threose, ribose, arabinose, xylose, lyxose, dihydroxyacetone, erythrulose, xylulose, aldoses, or ketoses.
7. The polymer of claim 6 comprising at least three alcoholic moieties derived from an aliphatic diol, triol, or polyol.
8. The polymer of claim 2 wherein the acidic moiety is derived from at least one of straight chain aliphatic diacids having 2 to 20 carbon atoms.
9. The polymer of claim 2 wherein the acidic moiety is derived from at least one of oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azaleic acid, sebacic acid, terephthalic acid, malic acid, fumaric acid, citric acid, citramalic acid, tricarballic acid, tartaric acid, isophthalic acid, phthalic acid, 1,6-bis(p-carboxy phenoxy)hexane, 1,3-bis(p-phenoxy carboxy)propane, 1,4-bis(p-phenoxy carboxy)butane, dodecanedioic acid, tetradecanedioic acid, hexadecanedioic acid, or oligomeric diacids with anhydride bonds in the backbone.
10. The polymer of claim 9 wherein oligomeric diacids with anhydride bonds in the backbone are selected from poly(sebacic anhydride), poly(suberic anhydride), poly(adipic anhydride), poly(succinic anhydride), poly(maleic anhydride), poly(1,6-bis(p-phenoxy carboxy)hexane), poly(1,4-bis(p-phenoxy carboxy)butane), poly(1,3-bis(p-phenoxy carboxy)propane), and poly(1,4-dicarboxybenzene).
11. The polymer of claim 9 comprising at least two acidic moieties each derived from a different polycarboxylic acid.
12. The polymer of claim 2 wherein the biobeneficial moiety, the non-fouling moiety, or the bioactive moiety are selected such that they give rise to a released molecule that can pass through a mammalian kidney.
13. The polymer of claim 12 wherein the biobeneficial moiety, the non-fouling moiety, or the bioactive moiety are selected such that the released molecule has a molecular weight of less than or equal to 40,000 daltons.

14. The polymer of claim 2 wherein the biobeneficial moiety is at least one of the polyethylene glycol, polypropylene glycol, block polymer surfactants of polyethylene glycol and polypropylene glycol, hydroxy functional poly(vinyl pyrrolidone), dextran, dextrin, sodium hyaluronate, heparin, elastin, chitosan, water-soluble derivatives of heparin, water-soluble derivatives of elastin, water-soluble derivatives of chitosan, tropoelastin, Albumin, poly(2-hydroxyethyl methacrylate), heparin, hirudin, or sulfonated polystyrene.
15. The compound of claim 1 wherein the formula is

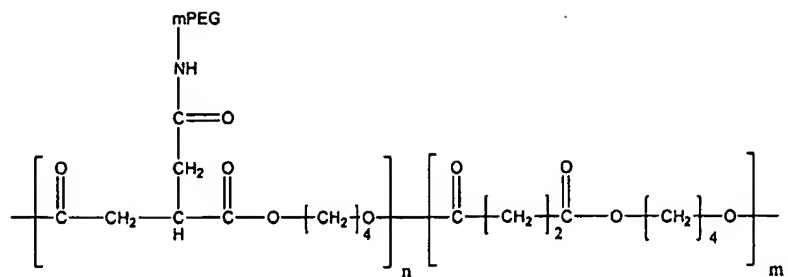


wherein L represents a cross-linking group or hydrogen.

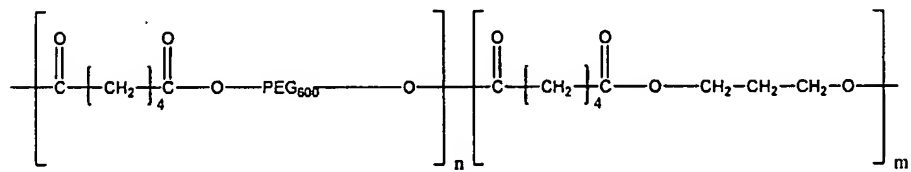
16. The compound of Claim 1 wherein the formula is



or



17. The compound of Claim 1 wherein the formula is



18. A block copolymer comprising at least two blocks wherein:

- a) the first block comprises a block copolymer comprising:
 - i) a first-block alcoholic moiety derived from a di-, tri-, or poly-ol; and
 - ii) a first-block acidic moiety derived from a di-, tri-, or poly-acidic carboxylic acid; and
- b) the second block comprises a block copolymer comprising:
 - i) a second-block alcoholic moiety derived from a di-, tri-, or poly-ol; and
 - ii) a second-block acidic moiety derived from a di-, tri-, or poly-acidic carboxylic acid

wherein at least one of the first- or second-block alcoholic moieties or first- or second-block acidic moieties is or attaches to a biobeneficial moiety.

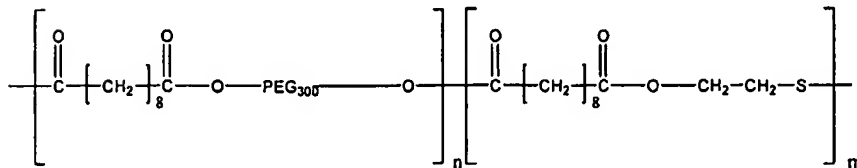
19. The copolymer of claim 18 further comprising a third block comprising a block copolymer comprising:

- a) a third-block alcoholic moiety derived from a di-, tri-, or poly-ol; and

- b) a third-block acidic moiety derived from a di-, tri-, or poly-acidic carboxylic acid.
20. The copolymer of claim 18 wherein the first- and the second-block alcoholic constituents are independently derived from 1-to-50-carbon-atom molecules.
21. The copolymer of claim 20 wherein the first- and the second-block alcoholic moieties are independently derived from 1-to-10-carbon-atom molecules.
22. The copolymer of claim 18 wherein first- and second-block alcoholic moieties are independently derived from at least one of ethylene glycol, 1,2-propane diol, 1,3-propane diol, 1,4-butanediol, 1,5-butanediol, 1,6-hexanediol, 1,7-heptanediol, 1,8-octanediol, higher diols up to C₁₆, glycerol, trimethylol propane, pentaerythritol, cyclohexanedimethanol, serinol, diethanolamine, or saccharides.
23. The copolymer of claim 22 wherein saccharides are selected from erythrose, threose, ribose, arabinose, xylose, lyxose, dihydroxyacetone, erythrulose, xylulose, aldoses, or ketoses.
24. The copolymer of claim 18 wherein the first- and second-block acidic moieties are independently derived from 1-to-50-carbon-atom molecules.
25. The copolymer of claim 24 wherein the first- and the second-block acidic moieties are independently derived from 1-to-10-carbon-atom molecules.
26. The copolymer of claim 18 wherein the first- and the second-block acidic moieties are independently derived from at least one of oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azaleic acid, sebacic acid, terephthalic acid, malic acid, fumaric acid, citric acid, citramalic acid, tricarballic acid, tartaric acid, isophthalic acid, phthalic acid, 1,6-bis(p-carboxy phenoxy)hexane, 1,3-bis(p-phenoxy carboxy)propane, 1,4-bis(p-phenoxy carboxy)butane, dodecanedioic acid, tetradecanedioic acid, hexadecanedioic acid, or oligomeric diacids with anhydride bonds in the backbone.

27. The copolymer of claim 26 wherein oligomeric diacids with anhydride bonds in the backbone are selected from poly(sebacic anhydride), poly(suberic anhydride), poly(adipic anhydride), poly(succinic anhydride), poly(maleic anhydride), poly(1,6-bis(p-phenoxy carboxy)hexane), poly(1,4-bis(p-phenoxy carboxy)butane), poly(1,3-bis(p-phenoxy carboxy)propane), and poly(1,4-dicarboxybenzene).
28. The copolymer of claim 18 wherein the biobeneficial molecule is selected from molecules that impart the characteristic of being biobeneficial.
29. The copolymer of claim 28 wherein the biobeneficial molecule is at least one of the polyethylene glycol, polypropylene glycol, block copolymer surfactants of polyethylene glycol and polypropylene glycol, hydroxy functional poly(vinyl pyrrolidone), dextran, dextrin, sodium hyaluronate, heparin, elastin, chitosan, water-soluble derivatives of heparin, water-soluble derivatives of elastin, water-soluble derivatives of chitosan, tropoelastin, Albumin, poly(2-hydroxyethyl methacrylate), heparin, hirudin, or sulfonated polystyrene.
30. A method for preparing the polymer of claim 1 comprising:
- a) preparing a polymerizable biobeneficial moiety based on BB;
 - b) polymerizing a polycarboxylic acid based on Q with the polymerizable biobeneficial moiety;
 - c) then polymerizing a mixture of a polycarboxylic acid based on Q', a di-, tri-, or polyol based on T, and the product of b).
31. The method of claim 30 wherein preparing a polymerizable biobeneficial moiety based on BB comprises connecting a biobeneficial moiety, BB, to a di-, tri-, or poly-ol based on W.
32. A method for preparing the polymer of claim 1 comprising:
- a) polymerizing a polycarboxylic acid based on Q with the biobeneficial moiety, BB; and
 - b) then copolymerizing a polycarboxylic acid based on Q', a di-, tri-, or polyol based on W, and the product of a).

33. A medical device comprising the polymer claim 2.
34. A medical device comprising the polymer claim 3.
35. A medical device comprising the polymer claim 12.
36. A medical device comprising the polymer claim 18.
37. A composition comprising a first polymer blended with the polymer of claim 2.
38. The composition of claim 38 wherein the first polymer modulates biological outcome.
39. The composition of claim 37 wherein the first polymer comprises polycaprolactone, poly(D,L-lactide), poly(L-lactide), poly(D,L-lactide-co-L-lactide), poly(glycolide), poly(D,L-lactide-co-glycolide), poly(dioxanone), poly(4-hydroxybutyrate), poly(3-hydroxybutyrate), poly(3-hydroxy valerate), poly(hydroxybutyrate-co-hydroxyvalerate), poly(tyrosine derive carbonates), poly(tyrosine arylates), poly(imino carbonates), poly(trimethylene carbonate), poly(anhydrides), poly(orthoesters), or poly(ester amides).
40. The composition of claim 38 wherein the first polymer comprises polycaprolactone, poly(D,L-lactide), poly(L-lactide), poly(D,L-lactide-co-L-lactide), poly(glycolide), poly(D,L-lactide-co-glycolide), poly(dioxanone), poly(4-hydroxybutyrate), poly(3-hydroxybutyrate), poly(3-hydroxy valerate), poly(hydroxybutyrate-co-hydroxyvalerate), poly(tyrosine derive carbonates), poly(tyrosine arylates), poly(imino carbonates), poly(trimethylene carbonate), poly(anhydrides), poly(orthoesters), or poly(ester amides).
41. A polymer with the following formula:



wherein S represents sulfur.

INTERNATIONAL SEARCH REPORT

PCT/US2004/015446

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C08G63/668 C08G63/688 C08G63/20 C08G63/685 C08L67/02
C08L67/04 C08L69/00 C08L73/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C08G C08L C08B C08H A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HU S.G. & AL: "Surface grafting of polyester fiber with chitosan and the antibacterial activity of pathogenic bacteria" JOURNAL OF APPLIED POLYMER SCIENCE, vol. 86, 2002, pages 2977-2983, XP002301919 page 2978 - page 2979; figure 1	2,14,33
X	NOUAIMI M. & AL: "Immobilization of trypsin on polyester fleece via different spacers" ENZYME AND MICROBIAL TECHNOLOGY, vol. 29, 2001, pages 567-574, XP002301920 page 568, left-hand column - page 569, left-hand column page 570, left-hand column - page 571, left-hand column; table 1 ----- -/--	2,14,33

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

Z document member of the same patent family

Date of the actual completion of the international search

21 October 2004

Date of mailing of the international search report

03/11/2004

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Masson, P

INTERNATIONAL SEARCH REPORT

PCT/US2004/015446

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN - & JP 07 330954 A (SHOWA HIGHPOLYMER CO LTD), 19 December 1995 (1995-12-19) abstract -----	2
A	RUEDIGER A., STRECKER H. & FRENCH D.M.: "The determination of reactive group functionality from gel-point measurements" JOURNAL OF APPLIED POLYMER SCIENCE, vol. 12, 1968, pages 1697-1712, XP002301921 tables -----	16
A	WO 00/77069 A (LERICHE CHRISTIAN ; LIMOUSIN ISABELLE (FR); BOCCIA HENRI (FR); GEMPLUS) 21 December 2000 (2000-12-21) page 2, line 30 - page 4, line 30 page 6, line 3 - line 7; claims; examples -----	1-41
X	US 4 350 806 A (WAGENER KENNETH B) 21 September 1982 (1982-09-21) column 2, line 15 - line 50 column 2, line 64 - column 7, line 27; claims; examples -----	1-5, 9, 12-14, 18, 19, 21, 24-36
X	EP 1 038 538 A (ISOTIS B V) 27 September 2000 (2000-09-27) column 2, line 15 - line 35 column 2, line 48 - column 3, line 22 column 3, line 46 - line 52; claims; examples -----	2, 33
X	WO 00/62630 A (UNIV WM MARSH RICE) 26 October 2000 (2000-10-26) page 3, line 5 - line 13; figures 1-3 page 4, line 8 - page 5, line 21 page 6, line 20 - line 30; claims; examples ----- ----- -/--	2, 33

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SEPULCHRE M. & AL: "WATER-SOLUBLE POLYMERS BEARING BIOLOGICALLY ACTIVE RESIDUES, SYNTHESIS AND CHARACTERIZATION OF POLY(ETHER-ESTER)S BEARING HYDROXYL SIDE GROUPS AND THEIR DERIVATIZATION WITH 1-NAPHTHYLACETIC ACID" MAKROMOLEKULARE CHEMIE, MACROMOLECULAR CHEMISTRY AND PHYSICS, HUTHIG UND WEPF VERLAG, BASEL, CH, vol. 194, no. 4, 1 April 1993 (1993-04-01), pages 1065-1078, XP000360572 ISSN: 0025-116X the whole document	1-41
X	----- US 5 854 368 A (TANI NOBUTAKA ET AL) 29 December 1998 (1998-12-29) column 1, line 9 - line 16 column 2, line 21 - line 44 column 3, line 27 - line 62 column 4, line 22 - line 33 column 7, line 56 - line 59 -----	2,33,36
A	WO 97/47670 A (UNIV MINNESOTA) 18 December 1997 (1997-12-18) page 3, line 30 - page 4, line 14 page 15, line 3 - page 16, line 13 page 17, line 5 - page 20, line 5 page 10, line 27 - page 11, line 19; claims; examples	1-41
X	----- BONZON N ET AL: "New bioactivation mode for vascular prostheses made of Dacron® polyester" BIOMATERIALS, ELSEVIER SCIENCE PUBLISHERS BV., BARKING, GB, vol. 16, no. 10, 1995, pages 747-751, XP004032918 ISSN: 0142-9612 page 747, right-hand column - page 748, left-hand column; figure 1 -----	2,33
A	EP 0 987 284 A (CANON KK) 22 March 2000 (2000-03-22) page 2, line 50 - page 3, line 26; table 3 -----	1-41
X	WO 99/55760 A (ORSOLINI PIERO ; DEBIO RECH PHARMA SA (CH); FERRUTI PAOLO (IT)) 4 November 1999 (1999-11-04) page 1 - page 3; examples 3-5 -----	2,33
X	EP 0 759 459 A (TEIJIN LTD) 26 February 1997 (1997-02-26) page 4, line 36 - page 5, line 24 -----	37-40

INTERNATIONAL SEARCH REPORT

PCT/US2004/015446

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	YAN L ET AL: "NEW BIODEGRADABLE POLYMERS FROM RENEWABLE SOURCES - SEGMENTED COPOLYESTERS OF POLY(1,3-PROPANEDIOL SUCCINATE) AND POLY(ETHYLENE GLYCOL)" RAPRA ABSTRACTS, PERGAMON PRESS LTD. OXFORD, GB, vol. 39, no. 10, October 2002 (2002-10), page 119, XP001133153 ISSN: 0033-6750 abstract -----	41
A	US 3 908 201 A (JONES EILEEN ET AL) 30 September 1975 (1975-09-30) the whole document -----	1-41
A	US 5 779 729 A (SEVERINI ALDO) 14 July 1998 (1998-07-14) the whole document -----	1-41
A	EP 0 797 963 A (CORVITA CORP) 1 October 1997 (1997-10-01) the whole document -----	1-41

INTERNATIONAL SEARCH REPORT

PCT/US2004/015446

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claim 1 discloses a polymer which can be one of formula (1) to (6). These formulae concerns (co)polyester which are characterised by a "biobeneficial moiety" . Since it is not clear at all to what relates such term, such characterization as such cannot be taken into account for the characterization of such polymers. Regarding claim 2, the same remark applies also since the expressions "bioactive and the anti-fouling moieties" are not sufficiently clear to make a meaningful search possible.

The same remark applies also to claims 18, 30, 32,33 and 36.

Thus, the set of claims has been searched with the limitation of such biobeneficial moieties defined in claims 14 and 29 (cf also description p 7 ; lines 23 to 31)).

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

PCT/US2004/015446

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP 07330954	A	19-12-1995	JP 3363589 B2	08-01-2003
WO 0077069	A	21-12-2000	FR 2795078 A1	22-12-2000
			AU 5228800 A	02-01-2001
			CN 1370190 T	18-09-2002
			EP 1192202 A1	03-04-2002
			WO 0077069 A1	21-12-2000
US 4350806	A	21-09-1982	NONE	
EP 1038538	A	27-09-2000	EP 1038538 A1	27-09-2000
			AU 3464900 A	09-10-2000
			CA 2366931 A1	28-09-2000
			EP 1163017 A1	19-12-2001
			JP 2002540082 T	26-11-2002
			WO 0056374 A1	28-09-2000
			US 2002072798 A1	13-06-2002
WO 0062630	A	26-10-2000	AU 775913 B2	19-08-2004
			AU 4349600 A	02-11-2000
			AU 760358 B2	15-05-2003
			AU 4351800 A	02-11-2000
			AU 770579 B2	26-02-2004
			AU 4644700 A	02-11-2000
			CA 2369758 A1	26-10-2000
			CA 2370330 A1	26-10-2000
			CA 2370357 A1	26-10-2000
			EP 1210379 A1	05-06-2002
			EP 1171006 A1	16-01-2002
			EP 1194463 A1	10-04-2002
			JP 2002542339 T	10-12-2002
			JP 2002542349 T	10-12-2002
			JP 2002542352 T	10-12-2002
			WO 0063263 A1	26-10-2000
			WO 0063268 A1	26-10-2000
			WO 0062630 A1	26-10-2000
			US 2002177668 A1	28-11-2002
			US 6306821 B1	23-10-2001
			US 6423790 B1	23-07-2002
			US 2002022676 A1	21-02-2002
US 5854368	A	29-12-1998	JP 3167156 B2	21-05-2001
			JP 5140276 A	08-06-1993
			JP 3167158 B2	21-05-2001
			JP 5148348 A	15-06-1993
			DE 69229710 D1	09-09-1999
			DE 69229710 T2	02-03-2000
			EP 0542299 A2	19-05-1993
			US 5576020 A	19-11-1996
			US 5644012 A	01-07-1997
WO 9747670	A	18-12-1997	AU 3227297 A	07-01-1998
			CA 2226946 A1	18-12-1997
			EP 0843692 A1	27-05-1998
			JP 11511804 T	12-10-1999
			WO 9747670 A1	18-12-1997
EP 0987284	A	22-03-2000	EP 0987284 A1	22-03-2000

INTERNATIONAL SEARCH REPORT

Information on patent family members

PCT/US2004/015446

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0987284	A	JP 3323836 B2 JP 2000297205 A US 6252027 B1	09-09-2002 24-10-2000 26-06-2001
WO 9955760	A 04-11-1999	FR 2777895 A1 AT 242285 T AU 760217 B2 AU 4136199 A CA 2330498 A1 DE 69908584 D1 DE 69908584 T2 WO 9955760 A1 EP 1076671 A1 ES 2199574 T3 JP 2002513055 T US 6660810 B1	29-10-1999 15-06-2003 08-05-2003 16-11-1999 04-11-1999 10-07-2003 29-04-2004 04-11-1999 21-02-2001 16-02-2004 08-05-2002 09-12-2003
EP 0759459	A 26-02-1997	AU 706442 B2 AU 6197996 A CA 2183412 A1 CN 1149601 A , B DE 69611405 D1 DE 69611405 T2 EP 0759459 A2 JP 3251507 B2 JP 9249805 A KR 230631 B1 US 5849822 A JP 9176412 A	17-06-1999 20-02-1997 18-02-1997 14-05-1997 08-02-2001 23-08-2001 26-02-1997 28-01-2002 22-09-1997 15-11-1999 15-12-1998 08-07-1997
US 3908201	A 30-09-1975	GB 1425577 A AU 5692773 A DE 2332248 A1 FR 2190399 A1 IL 42504 A IT 990717 B JP 50106497 A US 4042978 A	18-02-1976 19-12-1974 17-01-1974 01-02-1974 30-09-1976 10-07-1975 21-08-1975 23-08-1977
US 5779729	A 14-07-1998	IT MI931176 A1 AT 174517 T DE 69415212 D1 DE 69415212 T2 DK 627226 T3 EP 0627226 A1 ES 2124811 T3	05-12-1994 15-01-1999 28-01-1999 12-05-1999 23-08-1999 07-12-1994 16-02-1999
EP 0797963	A 01-10-1997	AU 726137 B2 AU 1650797 A CA 2199890 A1 EP 0797963 A2 JP 10005345 A KR 262836 B1 NO 971385 A US 5968091 A	02-11-2000 02-10-1997 26-09-1997 01-10-1997 13-01-1998 01-08-2000 29-09-1997 19-10-1999